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REPORT OF THE ENTOMOLOGIST.

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 1, 1921.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1921.

L. O. HOWARD,
Entomologist and Chief of Bureau.

HON. H. C. WALLACE,
Secretary of Agriculture.

CEREAL AND FORAGE INSECT INVESTIGATIONS.

W. R. Walton has continued in the leadership of the important work of this section.

EUROPEAN CORN BORER.—The changes in the aspect of the corn borer problem during the past year have not been so great as in former years. The larger appropriation which became available June 7, 1920, made it possible to do better and more extensive scouting work, so that the bureau has been able to keep track of the natural spread of the insect. The apparent increase of the infested area may thus, with reasonable certainty, be said to have been comparatively insignificant in United States territory. The total infested area in the United States at present is 4,629 square miles, of which 2,323 occur in eastern Massachusetts, including a slight extension north of the border line, since in October, 1920, the insect was found in the town of Eliot, Me., close to the New Hampshire border and in the extreme southeastern corner of the State. This particular area is small and does not apparently extend beyond 25 square miles.

The most important development of the year was the discovery during August, 1920, of a rather large infested area in southern Ontario bordering the northern shore of Lake Erie. While this is not in the United States, it has a great bearing on our agriculture, since the frontier of infestation in America is carried at least 125 miles farther west. The western edge of this Canadian spread reaches within 30 miles of the southeastern border of Michigan, and thus offers a great menace to the corn-belt States.

As a result of this unexpected emergency, it has been necessary for the bureau to assume a portion of the duties of the port inspection service of the Federal Horticultural Board.

The inspection work which was necessary to allow the movement of plants included in the quarantine of the Federal Horticultural Board has been very heavy, and approximately 500,000 inspection certificates were issued between March 29 and December 1. In this inspection, many hundreds of corn borer larvæ were found in crops

intended for shipment outside the infested area, and such shipments were intercepted. The unrestricted movement in all directions of motor vehicles coming from infested territory and headed frequently for points many hundreds of miles away was a source of great embarrassment to the quarantine officers, since many of these vehicles carried possibly infested garden products. For example, an inspection of such vehicles at a point on the Massachusetts and New Hampshire State line in a single day showed 75 dozen ears of corn and quantities of beans that had been bought in the infested area and much of which contained corn borers. Four thousand five hundred automobiles crossed the line at this point in a day. Additional legislation is necessary to enable the Federal quarantine officers to act drastically in such cases.

The scouting work has been very extensive, and, in the States known to be infested, covered more than 80,000 square miles. Some scouting was carried on also in 25 additional States, particularly in corn-belt States of the Middle West, but with negative results, and no corn borers were found west of Chautauqua County, N. Y. The small infestation in Erie County, Pa., mentioned in my last annual report, was apparently eradicated during the summer of 1919.

A large amount of artificial control work was done in the New England area between the fall of 1920 and the spring of 1921. The most intensely infested areas, including the market-garden regions near Boston, were covered. Special machinery for burning, steaming, crushing, and the chemical destruction of infested plants was largely used. The idea was to reduce the extent of the natural spread of the insect. In the same way 25 square miles around the village of Silver Creek, N. Y., was thoroughly cleaned up. The cornstalks, stubble, and so on were burned. The results of this work have not been encouraging and show that little can be done in this way, except in the case of isolated infestations, where there is a chance of total extermination. There remains, then, in addition to quarantine efforts and all other possible means of restricting the spread, the chance of natural control.

As indicated in my last annual report, an expert agent of the bureau was located in southern France and has now for more than a year succeeded in sending to the United States large quantities of the natural insect enemies of the borer, and about 6,000 adult parasites of two or more species brought over from Europe have been liberated in the cornfields of eastern New England. We expect to import increasing quantities of these parasites during the coming year.

The reduction of 30 per cent in the amount appropriated for this project has rendered it necessary to abandon other control measures in order to provide for the quarantine, scouting, and parasite introduction work.

GRASSHOPPERS.—Owing to the serious outbreaks of grasshoppers in North Dakota and the surrounding States during the past three years many appeals were made to Congress and the department for help, and the sum of \$40,000 was appropriated to be available July 1, 1921. An expert was appointed April 1 to survey the field and to plan for the necessary work when the appropriation should become available. He has been able to furnish valuable advice and assistance

during the most critical weeks of the grasshopper season to the States of Minnesota, North Dakota, Montana, and Wyoming. At the present writing the very serious grasshopper outbreaks which have prevailed in North Dakota for the past three years show very definite signs of abatement.

CRANE-FLIES.—For a long time the grass on cattle ranges in the interior valleys of California has been seriously injured at times by wormlike maggots which are the larvæ of certain crane-flies. Study has shown that these maggots come to the surface of the ground during the night in order to feed upon the tender grass, and in consequence of this habit experiments were made with poisoned-bran baits such as are used against grasshoppers and cutworms. The results were surprising, and it was found that at a cost of about 50 cents per acre 70 to 90 per cent of the maggots can be killed. Exact instructions are given in Department Circular No. 172, published in May, 1921.

THE HESSIAN FLY.—The general wave of Hessian fly abundance and injury mentioned in my last annual report has not increased in intensity during the past year. In the winter-wheat belt cooperative control campaigns conducted by the State and Federal authorities have been instrumental in materially reducing the injury caused by this well-known pest. The results obtained in Ohio, Indiana, and Illinois have been especially gratifying, as both the amount and intensity of the infestations of the Hessian fly have been materially reduced during the past 12 months, although the situation is still unsafe. Infestation in the Eastern States has also declined.

THE CHINCH BUG.—Damage from chinch bugs has continued to be serious in Missouri, Illinois, Indiana, and parts of Ohio. Agents of the bureau have been active in cooperating with State officials in order to reduce to a minimum the damage caused by this insect. A new farmers' bulletin containing entirely original and important information on the use of contact insecticides as a means of destroying chinch bugs is in press.

THE ALFALFA WEEVIL.—The alfalfa weevil has now reached the Nevada-California border and has recently been intercepted by California inspectors in the baggage of tourists who had been camping in Washoe County, Nev. It is probably present in all of the alfalfa-growing regions of Idaho, and may possibly have entered eastern Oregon. It also occurs in the western third of Colorado. Although a very effective means of spraying for the control of this insect has been developed, as mentioned in my last annual report, it has been decided to supplement this by a further effort to introduce into this country other European natural enemies of this pest. One species which was introduced before the war has become established, and is doing effective work in certain localities, but we know that there are other species that occur in the natural home of the weevil, namely, southern Europe, and an expert assistant has been sent to southern France to make further studies and further efforts to send over additional species of parasites.

THE SO-CALLED GREEN-BUG.—For the first time in several years the present spring was marked by a green-bug scare. The abnormally mild temperature of the past winter favored the great multiplication of this insect, and during the late winter it was present in great

numbers in northern Texas. Grayson, Denton, and Collin Counties were especially involved, but 10 or more of the northern tier of counties were included in the outbreak. As the season advanced the insect appeared in smaller numbers in Oklahoma, Kansas, and Missouri. Had the weather continued cool and wet the outbreak might have become disastrous, but during March and early April dry, warmer weather came and the parasites of the green-bug increased until by the middle of April they were in full control; so that, although the oats crop of northern Texas was seriously injured, the damage to winter wheat was comparatively slight.

A careful study of this outbreak was carried on cooperatively between the bureau and the officials of the States concerned, and it was shown that these outbreaks start in fields where volunteer oats have been allowed to stand over from the previous year, and there is little or no evidence to show that the outbreaks in Kansas, Missouri, and Oklahoma were the results of migrations of the insect from Texas. It seems that, if permanent control of the green-bug in northern Texas is to be brought about, it will be necessary for farmers in that region to abandon the practice of allowing and encouraging the growth of volunteer oats and wheat, since these provide continuous breeding places and shelter for the green-bug during the latter half of the summer and fall. Therefore an educational campaign by county agents and extension organizations should at once be begun to induce the farmers of those regions to destroy volunteer grain.

OTHER INVESTIGATIONS.—An investigation of the insects affecting sunflower plants has been started, since this plant is becoming adopted as a silage crop in certain portions of the West where corn can not be successfully grown.

The wheat midge, an insect which has done little or no damage in this country for the past 50 years, has been progressively injurious during the past 2 years in eastern Washington and Oregon as well as in the northern tier of mid-Western States, and an investigation has been begun.

With the introduction of the hairy vetch as a forage and seed crop in the Carolinas, the corn earworm, or cotton bollworm, or tomato fruitworm, as it is called when it affects these different crops, has taken to the vetch with avidity. An investigation of its habits in this connection has been made, and a Farmers' Bulletin (No. 1206) concerning methods of control has been published.

STORED-PRODUCT INSECT INVESTIGATIONS.

This important work has been continued under the direction of Dr. E. A. Back.

INSECTS ATTACKING CORN AND GRAIN PRODUCTS.—The research laboratory at Orlando, Fla., has been investigating especially the corn weevil under semitropical conditions. These investigations have been highly successful in procuring data for the most part entirely new to science.

The laboratory originally established at Athens, Ga., and which was moved to Thomasville, Ga., has been working in cooperation with the Georgia Agricultural Experiment Station and has aroused the interest of a number of prominent farmers and agricultural organi-

zations in the subject of the totally unnecessary destruction of corn by weevils on southern farms. State officials have estimated that this loss averages fully 10 per cent in the South. Corn weevils can be successfully controlled by the intelligent application of the recommendations of the bureau. The beneficial results are immediate and perfectly plain, and have already paid many times the cost of the research work connected with the problem.

BEAN AND PEA WEEVILS.—Investigations of losses to beans and peas grown in California and elsewhere have been continued at the laboratory at Alhambra, Calif. In addition to life-history studies, the problem of control by cold storage and by fumigation has been studied. Important facts have been ascertained. The work continues to receive the hearty cooperation of bean growers and warehousemen on the Pacific coast, and the information which has been secured out there has been applied successfully in the protection of beans, peas, and cowpeas in other parts of the country.

PEANUT INSECTS.—Market conditions during the past year have been such that large stocks of peanuts have remained unsold, and many requests have been received for methods of protecting them from insect attack; and insects have been unusually abundant. Experiments have been made which show that peanuts in the shuck can be held indefinitely if properly fumigated.

INSECTS AFFECTING HIDES.—At the request of certain leather manufacturers, an investigation of this problem was begun during the year. It is estimated that the hide beetle damages baled skins and hides in warehouses to such an extent that \$1,000,000 are lost each year. This loss can be largely prevented by fumigation if the hides are held in storage, and the process recommended does not injure even the most delicate skins.

INSECTS AFFECTING MEAT.—Experts of the Bureau of Animal Industry state that meats worth over \$1,000,000 are condemned annually by its inspectors as a result of insect infestation. Of these insects, the so-called ham skipper, the larva of a small fly, is probably the most serious. An investigation of the insects of this class was begun during the year, important life-history data have been secured, and experimental control work has been started.

INSECTS AFFECTING STORED WOOL.—Owing to economic conditions, large stocks of raw wool have been held in warehouses during the past year, and insects attacking raw wool, feathers, and bristles, and articles manufactured from these stocks, have had an unusual opportunity for development and spread. The ordinary clothes moths have been very destructive to certain supplies of baled wool. An investigation of the biology of the southern clothes moth has resulted in information of much value, not only to owners of raw wool, but to the manufacturers of brushes, upholstered furniture, clothing, weather stripping, etc. In a single case clothes moths injured a consignment of weather stripping to the extent of \$2,000. Such losses as this need not occur if methods recommended by the bureau are followed.

THE CEDAR CHEST AS A PROTECTION AGAINST CLOTHES MOTHS.—Cedar chests have long been popular on account of the supposed protection which they give to clothing stored in them. Their efficacy has been denied, and the truth of the matter has not hitherto been scientifically investigated. In cooperation with the drug, poisonous, and oil plant

investigations of the Bureau of Plant Industry an investigation of this question has been conducted, and the work has been followed closely by the National Cedar Chest Manufacturers' Association. It has been shown that cedar chests made of fresh red cedar can be depended upon to protect clothing provided the clothing has been properly prepared for storage. While the chests do not appear to affect adult moths or their eggs, the young larvæ hatching in the chests or accidentally introduced in the clothing are killed before they do damage. Old larvæ are not killed. The mortality among half to full grown larvæ is considerable, but many of the latter mature and transform.

INSPECTION AND INTELLIGENCE SERVICE.—The cooperation with the Army and Navy for the purpose of inspecting stored food supplies, not only at the time of purchase, but from time to time during storage, and the giving of the necessary expert advice following such inspection, has been continued in the way indicated in my last year's report.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS.

Dr. A. L. Quaintance has continued in charge of this important branch of the bureau work, and since the first of the year has also been charged with investigations of insects affecting tropical and subtropical fruits in cooperation in certain respects with the Federal Horticultural Board.

THE JAPANESE BEETLE.—In the last annual report the territory occupied by this imported pest was estimated to be approximately 50 square miles in the vicinity of Riverton, N. J. Since that time the area has been carefully scouted, and the beetle is now known to occupy 80 square miles in New Jersey and 10 square miles in adjoining regions in Pennsylvania. The quarantine operations, both by the Federal Government and the State of New Jersey, were continued and enforced during the summer and fall of 1920. In the spring of 1921 the quarantine was materially enlarged and was supplemented by a Pennsylvania quarantine. On account of the further spread of the insect five stations in the area were established for inspection purposes. It has been necessary to certify practically all farm products, but actual inspection has been necessary practically only with sweet corn. Sixty-two thousand baskets of corn were examined in 1920 and 846 beetles were found.

Control.—There has been a great deal of experimentation with poisons, but complete success has not been reached. In fact, no effective means of destroying the beetles has been found, although substances have been ascertained which will protect the foliage from their attack. A great deal of experimentation has been made in the search for chemicals which will kill the grubs in the ground, but nothing effective which is cheap enough has been found. Experiments are now being made in the disinfection of soil around the roots of certain classes of nursery stock in order that nurserymen may be able to move such plants from the infested areas. The barrier band described in my last report was discontinued at the close of 1920, since it did not appear sufficiently effective in preventing the spread of the beetles to justify the expense.

These difficulties have shown the need of a very detailed knowledge of the biology of the insect, and this work has been materially

strengthened in the hope that some peculiarity in the mode of life of the species will be discovered which will indicate some possible way of destroying it or reducing its numbers. Careful studies are being made of the types of vegetation, exposures, etc., that the beetles prefer, and also the exposures and types of soil preferred by the grubs. Based on this information, a study is being made of the value of agricultural methods in destroying the grubs in the soil.

Natural enemies.—In the fall of 1920 an additional investigator was sent to Japan to assist in the search for natural enemies and in sending them to New Jersey. The two agents in that country now, with the expert assistance of Japanese entomologists, have made a careful study of the distribution of the beetle over there, and several sendings of predatory and parasitic insects have been made and are now being given attention at the Riverton laboratory.

The native enemies of white grubs in other parts of this country have also been studied, and certain wasplike parasites have been shipped from the Middle West to New Jersey.

PEACH INSECTS.—For the past two or three years Georgia peach growers have experienced heavy losses from the plum curculio, and, on account of extensive appeals, a laboratory for the further study of this insect was established at Fort Valley, Ga., in the late fall of 1920. The Georgia State Board of Entomology is cooperating in this work, and the Bureau of Plant Industry is at the same time working on the fungous diseases of the peach. A mass meeting of Georgia peach growers was held at Fort Valley in December and a campaign was outlined. During the winter months all woodlands, waste lands, and fence rows adjoining peach orchards were cleaned up in the effort to destroy the hibernating beetles. The railroads cooperated by cleaning up waste growth along their rights of way. In the spring, spraying and dusting were begun, and through their committees orchardists were notified during the season of exact dates when applications should be made, with the result that through the entire belt effective work was done and an excellent crop of peaches was marketed with comparatively little curculio damage.

Work against the peach borer, especially with reference to paradichlorobenzene, has been continued. This treatment continues to be effective and safe when used according to directions and has come into large commercial use. There is still some experimental work to be done in order to settle certain practical points, such as safety to young trees, effect of soil temperatures, relation of moisture conditions of the soil, etc.

APPLE INSECTS.—Studies of the codling moth have been continued in the Yakima Valley, Wash., the Rogue River Valley, Oreg., the Ozark region of Arkansas, and in northern Georgia. Extensive experiments with sprays and dusts are in progress, and the comparative values of the methods of control by spray guns and by spray rods are being investigated, as well as the different types of power machinery and the value of adhesives in spray solutions. Shipments of parasitized codling-moth larvæ have been sent from the East to the State of Washington.

Certain city boards of health in California have been complaining for the past few years of the amount of spray residue found on pears sent to market, and on apples as well. Consequently a coopera-

tive investigation was begun with the State Department of Agriculture of California the past spring looking toward an improved method of controlling the codling moth on pears which will not leave the objectionable spray residue. The indications are that this work will be successful. The same work was extended to include apples and pears at the Oregon and Washington stations.

An investigation of apple leafhoppers has been begun, with headquarters at Bentonville, Ark. At this station the apple leaf-skeletonizer and the apple leaf-crumpler are being studied, since these insects are of considerable economic importance in that part of the country.

At the station at Wallingford, Conn., which is conducted in cooperation with the State agricultural experiment station, studies of the apple maggot have been continued, and experiments in several orchards with arsenate of lead indicate that this treatment has some value. At this station tests of contact dusts in the control of certain apple insects were made in 1920, which have been described in a publication by the Connecticut station.

NUT INSECTS.—The bureau has a station for the study of insects attacking northern nut crops at French Creek, Va., and one at Brownwood, Tex., where insects attacking the pecan are being investigated. At the northern station the walnut husk-maggot has been especially studied. This insect, in localities where the native black walnut abounds, is a serious pest of Persian and other introduced walnuts, promising crops of Persian walnuts having been entirely ruined by it. A preliminary paper has been published which deals with methods of control. At this station studies have also been made of snout-beetles which attack the young fruits of black walnut, the fruits and shoots of butternut, Japanese walnut, and other introduced walnuts of the butternut type, and others which attack hickory nuts and the shoots of hickory. The insects which cause wormy chestnuts are also being studied.

At the Texas station the worst pecan enemy is the case-bearer. Its life history has been carefully studied, and numerous experiments with arsenical dusts and sprays appear to show that the insect may be materially reduced in numbers where such treatments are practicable. In some sections the so-called obscure scale is a serious pest of the pecan, and the bureau's work shows that it can be controlled by spraying either with the commercial lime-sulphur solution or by oil emulsions during the dormant season. No good method of control has been found for the pecan weevil, although there still remain some hopeful lines of experimentation. The publication of a monographic report on the pecan insects of the Southwest is contemplated.

GRAPE INSECTS.—The work at the Sandusky, Ohio, laboratory has been continued in cooperation with the State agricultural experiment station. A marked improvement in the grape-growing industry has followed the general adoption by the growers of the spray formulas developed by the bureau. A high percentage of sound fruit has been obtained by following the two-spray schedule for the control of the berry moth. It has been found, however, that certain varieties of grape are subject to spray injury, and modifications of the mixtures are still to be worked out in such cases. It is believed that a single spraying, thoroughly done, will control the berry moth in vineyards which are not too seriously infested.

In the course of this work it has been shown that calcium arsenate, which is cheaper than arsenate of lead, can be successfully used in the control of the grape-berry moth on Concord grapes, but that it burns the leaves of Ives' Seedling and certain other varieties. Magnesium arsenate is more injurious than arsenate of lead, and can not be used. Fish-oil soap, casein, and other materials have been found to be valuable as adhesives and spreaders.

The grape leafhopper is just now causing premature falling of the foliage in northern Ohio, and poorly colored and poorly ripened grapes result, causing a depreciation last year in some cases of \$75 to \$100 per ton. Careful studies of this insect are now being made.

At Fresno, Calif., the bureau is experimenting with remedial operations on a commercial scale against the grape mealybug. This insect winters partly in the egg stage, which makes it very difficult to handle. Further tests with sulphur fumes, at one time recommended, have been abandoned, since it has been shown that they injure the plants and are not effective. Experiments are now going on with miscible oils, but conclusions have not been reached.

The large larva of the Achemon sphinx moth occurred again in alarming numbers in Merced County in July, 1921, stripping 100 acres of vineyards and causing the loss of 200 tons of grapes. This insect may be controlled by the use of arsenate of lead and sulphur dust, or with 5 pounds of the arsenate of lead to 200 gallons of spray, some glue being added to the spray to make it adhere.

INSECTICIDE INVESTIGATIONS.—Insecticides are so largely used in orchard work that Dr. Quaintance is naturally the representative of this bureau on the Federal Insecticide Board and handles in a general way the insecticide questions for the bureau. Year after year investigations of miscellaneous insecticides are continued under his direction. A comparative study of arsenicals as insecticides, in co-operation with the Bureau of Chemistry, was practically concluded at the close of the year, and a manuscript has been prepared for publication. It includes a study of raw materials, methods of manufacture, analyses, and classification of arsenicals, compatibility of insecticides and fungicides, relative toxicity of arsenicals, and so on. Many interesting results have been reached, most of which will be of practical application.

A study has been made of the insecticidal constituents of plants, and 180 different preparations have been made from 46 different kinds of plants, excluding tobacco, quassia, and derris, the properties of these being generally acknowledged. Of the 180 preparations, only a few are worth further study. The possible development of contact insecticides as a substitute for nicotine or tobacco extract has been investigated. It has been found that the most highly poisonous compounds are among the organic nitrogen compounds. Some of these, like pyridine, have but little toxic value, while others, like piperidine sulphate and trimethylamine hydrochlorid are decidedly toxic at less than 1 per cent concentration. A pyridine derivative, however, has been developed which promises success against soft-bodied insects. It has also been found that heavy petroleum-oil emulsions in a dilute condition will be useful against plant lice under certain conditions.

VEGETABLE AND TRUCK-CROP INSECT INVESTIGATIONS.

The work on this series of projects has been continued under the direction of Dr. F. H. Chittenden. The importance of this work has been greatly increased by the sudden appearance and rapid spread of the Mexican bean beetle in Alabama and adjoining States.

SWEET-POTATO WEEVIL ERADICATION AND CONTROL.—Work on the sweet-potato weevil in Florida and Georgia has continued. Inspection of the infested district in Baker County, Fla., shows a great reduction in the number of farms infested, these being in sections where it is difficult to secure cooperation from growers. In Charlton County, Ga., infested farms have been reduced to such an extent that only two are now known to be infested. Contracts have been signed with about 200 farmers for the delivery of weevil-free draws and seed sweet potatoes for the following spring. Hundreds of thousands of draws have been distributed in infested regions in cooperation with the Florida State Plant Board, as also many bushels of seed potatoes and vine cuttings. Experimental life-history work, including fumigation and the control of the weevil in seaside morning-glory vines, has been continued. Progress has been made in its control even in the presence of wild host plants. As a result of the work, it will be possible to declare two-thirds of the previously infested area weevil-free and all but a few of the infested farms in this area will probably be cleaned up during the year. Research work in south Texas has been completed and results are ready to publish. It has been demonstrated that adults can be starved out in between 9 and 37 days. In Alabama no new infestations have been found and that State, as well as Georgia, is considered practically weevil-free.

PREVENTING THE SPREAD OF THE MEXICAN BEAN BEETLE.—The Mexican bean beetle, an insect which has been known as a pest in New Mexico and neighboring States for about 50 years, was discovered in the vicinity of Birmingham, Ala., during the fall of 1920, where it has been accidentally introduced in alfalfa hay from Colorado. Preliminary scouting was carried out by the Alabama State Experiment Station, with which institution the bureau is now cooperating, to learn the general limit of infestation, but because of the lateness of the season and lack of funds this inspection could not outline the entire infested area, although the insect was found in about 13 counties in Alabama over an area of about 3,500 square miles.

When the Federal bill appropriating \$100,000, of which \$25,000 was immediately available, was passed March 3, 1921, the field work was organized in two main divisions—research and regulatory scouting. The research work consists of life-history and food-plant studies and tests of control measures. Up to the present distinct progress has been made along all research lines and a large series of dusts and sprays has been tested out on several complete experiments. While the insect made its appearance in the vicinity of Birmingham in March, it was much later in appearing around the outer edges of the known infested zone. In following up this work the insect was soon found in northeast Georgia in several counties, and from there was traced to the vicinity of Chattanooga, Tenn. These observations made it apparent either that the insect had been present for a much longer period than had been believed or that it spread more

rapidly than had been expected. It was then learned that about 10,000 square miles were quite generally infested with the bean beetle in 3 States—Alabama, Georgia, and Tennessee—and that infestation beyond this point, while scattered, is well established. Considering all reports of inspection up to July 19, 1921, the beetle has been found present in 30 counties in Alabama, covering an area of about 18,500 square miles; in Georgia the infestation covers 26 counties, with a total area of about 6,000 square miles; in Tennessee it covers 25 counties with a total area of about 8,000 square miles. In addition, the insect has been located in Whitley County in Kentucky and in Oconee County in South Carolina. With the exception of one locality the infested area apparently surrounds a central area of heavy infestation, the single exception being Thomasville, Ga. At the present time 83 counties in 5 States are known to be infested with the Mexican bean beetle, the area covering approximately 34,000 square miles. It is probable that the insect has spread largely by flight, since it is an unusually strong flier, and that it has also been spread to a lesser extent by commercial shipments of infested food plants and other crops and in hay along railways and the larger roads. The large shipping centers of Birmingham and Chattanooga are well within the infested territory, and the insect has been found within 17 miles of Atlanta, 16 miles of Knoxville, 36 miles of Montgomery, and 44 miles of Nashville. The infested territory reaches within 16 miles of Mississippi, 3 miles of North Carolina, 23 miles of Virginia, and 10 miles of Florida. While it is difficult to predict the future spread of this insect, it has very evidently gone beyond the bounds of control by human agencies, and the present infestation will probably spread rapidly within the next three years, and in time it may menace the principal bean-growing sections of the entire country east of the Mississippi River.

Since, then, the insect is apparently not amenable to control by quarantine, the most promising line for future work naturally follows research and extension. At the very outset it was discovered that the insect had not only acquired new food plants, especially cowpeas, but that it had acquired an entirely different life history in the warmer and longer season of Alabama and neighboring States, for whereas in Colorado in normal years the species produced only one and a partial second generation, in its eastern occurrence it will evidently produce four or five generations annually. Investigations are now being carried out to determine all possible food plants, including wild ones, which were never attacked in its western range and to secure, if possible, a resistant or semiresistant variety of beans, cowpeas, and other seeds which may be introduced from Mexico or elsewhere in the infested region. An expedition has been sent to Mexico and Central America to search for natural enemies, since tropical America is known to be the home of several related species of beetles with similar habits, none of which are known to be pests in those countries. Efforts will be made to introduce all possible natural enemies as well as to learn the habits of natural enemies in the known range of the Mexican bean beetle in this country. Similarly any resistant or semiresistant varieties of beans which may be found in Mexico will be introduced and thoroughly tested by every possible means. Large-scale work is also being conducted

to determine direct control measures which will make the growing of beans profitable and practical in the presence of the insect. The research work is still in its infancy, and to be effective should be carried on upon a larger scale wherever the insect is known to occur in the United States.

INSECTS INJURIOUS TO POTATO, TOMATO, AND RELATED CROPS.—Work on the Colorado potato beetle has been continued. Life-history work on this species has never been conducted in the South until the present year, when five generations were reared in Louisiana. Undiluted lead arsenate in different proportions combined with air-slaked lime was tested and gave very satisfactory results. The potato leafhopper, a small insect which is the cause of "hopperburn" or "leaf-burn" on potatoes in the potato-growing sections of the Northern States, has been very carefully studied in Wisconsin, and Farmers' Bulletin No. 1225, covering this subject, is in the printer's hands. A more detailed account has been prepared in cooperation with the Wisconsin State Experiment Station. It is a serious enemy of the potato as well as of the bean and sugar-beet crops in the Northern States, and the condition termed "hopperburn" may bring about the ruin of an entire crop in a very short period. It may be held in check by spraying with Bordeaux mixture. The tarnished plant-bug has been investigated from the standpoint of its occurrence in and near the District of Columbia, and its wild and other food plants on which the insect breeds have been thoroughly investigated. The control of the tomato fruitworm has been continued in Louisiana, where powdered calcium arsenate gave good results, as did also the planting of sweet corn as a trap for the worms to lure them from the tomato crop. The potato flea-beetle has been under continual observation, but of the various substances tested during the year none has proved better than Bordeaux mixture, a deterrent, and still the standard method for its control. Efforts are being made to introduce into France, Morocco, and western Australia one of the valuable parasites of the potato tuber moth which help to hold this pest in check in California.

INSECTS INJURIOUS TO BEANS AND PEAS.—As a result of the accidental introduction of the Mexican bean beetle into the Gulf States and the probability of its continued and rapid spread, additional work is demanded in the infested area, as also elsewhere; and because of the necessity of increasing the crops in regions which are bean-beetle free, it will be necessary to control all other important pests on beans and related crops. Thus the bean fly, or seed-corn maggot, which has been unprecedentedly injurious during the past spring almost throughout the Atlantic region, has been given additional study and its life history has been worked out. Sodium arsenate incorporated in a bran mash has proved highly effective, being both economical and rapid of action. We hope to try this on a large scale next spring and to test it against related root maggots. The bean leaf-beetle, which has been destructive in the Southern States, has also been studied. The pea aphid and the bean aphid have been very carefully studied on the Pacific coast, and a report on their life history and control has been prepared. Nicotine sulphate in a dust carrier has been found very effective as a remedy. The pea moth has been given additional study, and the work will be continued. The lima-bean symphylids

require study in the States of California and Idaho, where they are doing great damage to lima beans and some other crops.

INSECTS DESTRUCTIVE TO CABBAGE AND OTHER COLE CROPS.—The imported cabbage webworm has been studied in Louisiana, and both arsenate of lead and paris green, with laundry soap added as a spreader or sticker, have been found effective, while calcium arsenate and zinc arsenite sprays were ineffective. A preliminary account of the European horse-radish webworm, which recently made its appearance in injurious numbers in Virginia, has been completed, and the results are available for publication as Department Bulletin 966. A species of flea-beetle, previously unknown as a pest, has attracted attention in Monroe County, N. Y., and it would appear that infestation, which is principally to seedling radish, as also to turnip, cabbage, and related crops, is somewhat extensive. The brassy cabbage flea-beetle, a related species and also a new crop enemy, especially to turnip and mustard, has been carefully studied in Louisiana. It has been found to be extremely prolific, a single female depositing upward of 1,400 eggs, while 8 generations have been reared in less than a year. While not as yet a pest of great importance, it is likely to develop into one in the absence of its wild food plants.

CUCURBIT INSECTS.—Experimental work on the control of the striped cucumber beetle, which is not only directly injurious to all cucurbits but is the principal carrier of cucurbit diseases, has been continued, and tests have been made of new and promising insecticides and deterrents. Valuable data on the insect's behavior, including the discovery of two new early food plants, have been obtained. Of the various direct remedies tested, nicotine sulphate in dust form has proved the most promising in the vicinity of the District of Columbia, especially where applied by means of a knapsack bellows, when it proved to have between 90 and 100 per cent killing power. It forms a good covering over the plant and penetrates the earth around the base of the plant, driving the insects up from concealment and killing them. It also acts strongly as a deterrent. Plants thus treated produce full yields of fruit in spite of heavy infestation of the plants when very young. Another season's work will be necessary to determine if this effectiveness will hold for other regions.

SUGAR-BEET INSECTS.—Work on the sugar-beet leafhopper, the cause of "curly top" so injurious to the sugar-beet industry, has been continued in cooperation with the Bureau of Plant Industry. The principal investigation, in line with the most productive results already achieved, lies in the selection of resistant beets, of which last season more than 350 types were selected. These are being brought through to seed, after an all-winter's silage, in order to determine the percentage of resistant beets in each case, all selected separately receiving inoculation. The results to date are very promising. Department Bulletin No. 967 on the blister beetles affecting sugar beets and truck crops will soon be available, and two publications, including Farmers' Bulletin 1193, have been issued on the beet leaf-beetle dealing with appropriate control measures.

STRAWBERRY, BLACKBERRY, AND RASPBERRY INSECTS.—The strawberry weevil and strawberry leaf-roller, the two most important insect enemies of these crops, have been the subject of continued experiment in New Jersey during the year, and work on both forms is

nearly complete. A large series of insecticidal experiments against the former prove that dusting with sulphur 1 part and lead arsenate 5 parts, as developed at the New Jersey State station, is the best method of control. It acts first as a repellent and afterwards as a poison. Against the strawberry leaf-roller arsenate of lead, 3 pounds to 50 gallons of water, applied when the larvæ are just hatching from the egg, has proved the best remedy. In New Jersey it has been learned that 75 per cent of this pest is destroyed annually by a parasite new to science. Efforts will be made to introduce this natural enemy in other regions infested by the leaf-roller. Work has been continued on the borers which affect the canes of blackberry and raspberry.

EXPERIMENTS WITH NICOTINE SULPHATE IN CALIFORNIA.—Experiments with nicotine sulphate in a dust carrier have been conducted against truck-crop insects in California. Flowers of sulphur and lime are proved to absorb less nicotine than does kaolin, and hence are more satisfactory as carriers. Lime, however, tends to break up the nicotine sulphate and form calcium sulphate and free nicotine, resulting in such volatility that the mixture deteriorates very rapidly unless in hermetically sealed containers. This increases the commercial cost but results in increased effectiveness. A preliminary report of this work has been published as Department Circular 154.

A 2 per cent nicotine mixture by weight was found satisfactory for the control of the melon aphid. With hand dusters about 2 acres per diem per man can be covered, using from 30 to 50 pounds of dust. With a light power outfit, using two hoses and operated by a team and two men, 3 to 4 acres an hour can be covered, using 50 pounds dust to the acre. The cost of material ranges from \$4.50 to \$7.50 per acre.

For the pea aphid a dust containing at least 2.4 per cent of nicotine was required for a satisfactory kill. Many growers prefer to use a mixture containing 4 per cent nicotine (10 per cent of 40 per cent nicotine sulphate) which is very active. The cost of this is, however, prohibitive except with the most profitable crops, and spraying is accordingly advised in cannery and market fields. With one pint of 40 per cent nicotine sulphate to 100 gallons of water, a properly arranged spray boom, and a pressure of 200 pounds, the usual nicotine-soap mixture will secure good results at a cost of \$3 per acre.

WORK ON THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

Work on this project has been continued under the supervision of Mr. A. F. Burgess, with headquarters at Melrose Highlands, Mass. During the past year the work has been carried on in the face of unusual difficulties. The most careful estimate that could be made showed that \$400,000 would be necessary for the thorough scouting and treatment of the border area in New England, to enforce the quarantine, and to conduct the experimental work on which all sound methods of field operation must be based.

The area that it was necessary to scout and clean in order to prevent the spread of the insect to the west comprised two or more tiers of towns from the Maine-New Hampshire line and north of

Conway, N. H., extending to the Connecticut River, thence west of the river in Vermont and to the Massachusetts line, and southeasterly across Massachusetts and Connecticut to Long Island Sound.

To carry on this work an appropriation of only \$250,000 was made available for the fiscal year. And then, about the 1st of July, came staggering news. The gipsy moth was found near Prospect Park in Brooklyn. A few days later it was found on a large estate in Somerville, N. J., and the fact was soon established that at the latter place a large block of Koster spruce imported from Holland 10 years ago had brought over at that time (before the passage of the Federal horticultural law) egg masses of the gipsy moth, and that the moth had been multiplying there unnoticed during all these years. But this was not the worst, although several acres of these trees were found to be completely stripped: Trees from this estate, and in some cases from the infested spruce planting, had been sold nearly every year since the original trees were received from Holland. Fortunately, an accurate record of the shipping lists had been made, and these were secured so that the shipments could be traced. Two hundred and sixty-one shipments had been sent to 17 States outside of New Jersey, as follows: Connecticut, Delaware, District of Columbia, Florida, Illinois, Indiana, Kentucky, Maryland, Minnesota, Missouri, New York, North Carolina, Ohio, Pennsylvania, Virginia, and Wisconsin. In addition to these, 318 shipments had been sent out and planted in 72 different towns in New Jersey. And this was not all: Some of these trees had been bought by nurserymen and landscape architects, and had been reshipped to other points. This meant an enormous labor, but it is believed that all the stock that was sent out has been traced and the territory inspected, with the result that small infestations were found at Loretto, Pa.; Garrison, Roslyn, and Kew Garden, N. Y.; Deal Beach, Wykoff, South Orange, Scotch Plains, Paterson, Madison, Glenrock, and Elizabeth, N. J., and another infestation was found at Mendham, N. J., although this one might not have come from the Somerville colony.

Immediate steps were taken with the New York authorities and the Brooklyn Park Department to stamp out the Prospect Park outbreak, and the eradication of this colony is expected at an early date. When the Somerville, N. J., colony was found no State funds were available. Immediate arrangements were made to prevent entrance to the property, and the territory about was carefully scouted by selected scouts transferred from New England. They found about 100 square miles of infested territory. State quarantines were established and suspected products shipped from infested areas were inspected by employees of the bureau. Congress was asked for a deficiency appropriation of \$300,000, and by December 1, 1920, nearly all the bureau funds for field work had been exhausted. At a special session of the New Jersey Legislature in November \$112,000 was appropriated, and a large number of the New England field force were taken on the State pay roll, the work in New Jersey, however, being managed by the bureau in cooperation with the State. Early in March all of these State funds, together with \$25,000 furnished by the owner of the originally infested estate at Somerville, had been spent for labor or allotted for the supplies and spraying equipment for use late in the spring.

On March 3, 1921, a deficiency appropriation of \$225,000 was passed by Congress and approved by the President, and a hurried attempt was made to reorganize the force to carry on the spring and summer work in New Jersey, New York, and New England and to complete the scouting in New England that should have been done last winter.

It appears now that the infestations in New York are all of moderate size. They have been thoroughly treated in cooperation with the State authorities, \$25,000 having been appropriated by the State for this purpose. The Pennsylvania infestation is confined to a single estate, and work there and in a surrounding area has been done by the bureau cooperatively with the State officials.

In New Jersey the scouting operations carried on during the winter showed the insect present over an area of 417 square miles. In most of this territory the infestation is very slight, the worst section being in Somerville and south and east of this town. The egg clusters were thoroughly treated over the entire area during the winter, over 3,000,000 clusters being found in the spruce block where the infestation started. All badly infested spots, together with the entire infested estate, were thoroughly sprayed, some of the worst points being treated twice during the season. The result has been very satisfactory, but it is obvious that complete extermination of the insect in New Jersey can not be accomplished under four years of additional continuous and thorough work.

The infestations in New York and Pennsylvania are much smaller, and the insect should be eliminated in a shorter time.

The New England area has suffered severely during the past year because of our inability to do the necessary work at the proper time, on account of lack of funds. The border scouting had to be discontinued December 1 and could not be resumed until March 15. During the border scouting 65 towns were found to be infested—4 in New Hampshire, 31 in Vermont, 22 in Massachusetts, and 6 in Connecticut—and all of these were quarantined July 1. Very possibly other towns are infested that could not be reached during the past winter.

The progress of the imported natural enemies has been slow, and it varies from year to year. Some are affected adversely by severe winter weather, and, as most of the species are able to migrate considerable distances, their presence in a given area one year does not always give positive assurance that they will be found there in increasing numbers the following season. Some of the imported parasites have been unnoticed for years, and have reappeared. For example, in 1908 several shipments of a large ground beetle known as *Carabus auratus* were imported from France and colonized as a possible ally in controlling the gipsy moth. During the years that followed none were found, and the importation was thought to have been a failure. In the early summer of 1920, however, 12 years after its introduction, several specimens were collected a few miles from the place where it was liberated, and more have been found this year. The value of this predatory species as an enemy of the gipsy moth has not been demonstrated, but it does destroy large numbers of cutworms and soft-bodied insects. Nearly all of the introduced parasites that have become well established occurred rather abundantly last summer. In relatively few cases were they present in

sufficient numbers to bring about effective control, and it seems quite likely that further search for additional natural enemies in Europe and the reintroduction of some of the species that have not been recovered in New England might result in valuable assistance.

The brown-tail moth has been present in relatively small numbers during the past five years, and its natural enemies, and especially the introduced parasites, undoubtedly played an important part in bringing about this condition of affairs. It seems to be increasing of late, and has been more abundant this summer than during the previous year.

During the present summer at certain points in New England tree stripping has been very noticeable. In Massachusetts, east of Worcester, except toward the south, it has been bad. In New Hampshire, south of Lake Winnepesaukee and east of the watershed between the Connecticut and Merrimac Rivers, there was extensive stripping, and the same may be said of the southeastern part of Maine. Conditions on Cape Cod, however, were better than for several years past.

This moth work should be supported financially in a manner that will give adequate protection against the spread of the insects. If allowed to spread the loss will be enormous. Proper sums should be appropriated for the protection of the rest of the country. It will be very economical to do this, and it will be very extravagant in the long run not to do it.

SOUTHERN FIELD-CROP INSECT INVESTIGATIONS.

Investigations of insects affecting southern field crops have been continued under the direction of Dr. W. D. Hunter.

COTTON INSECTS.—Cotton boll weevil investigations have been centered around the newly developed process of controlling the weevil by dusting with dry powdered calcium arsenate. Plat tests have been conducted with the object of improving the poison used as well as improving the methods of application. The large-scale poisoning was still further extended during the season of 1920 to include something like 75,000 acres of treated cotton under the supervision of experts from the Delta laboratory. Practically all of this work was carried to a successful completion in spite of unfavorable conditions, and much information of value in outlining commercial practices was secured. A brief popular summary of rules for poisoning has been issued. This is being used very widely by farmers as a basis for their commercial poisoning.

The study of dusting machinery has been continued; numerous new machines put on the market by various manufacturers have been tested and modifications and improvements suggested. During the past season the Delta laboratory was able to develop the intermediate type of dusting machine which has been so long desired, and this was thoroughly tested. As a result of this work, there was issued a basis design on a one-mule, one-wheel, two-row type of dusting machine. This design was submitted to all interested manufacturers, and several have models on the market based on it. These machines are exceedingly simple and are available at approximately \$100 each, which means that the cost of dusting machinery for poisoning

is reduced practically one-half. Still other types of machines are in course of construction which, when completed, will be adapted to conditions for which we do not now have suitable machines.

The calcium arsenate inspection work has been maintained in co-operation with the Federal Insecticide and Fungicide Board. Something like 2,000 samples of calcium arsenate submitted by farmers were tested and the senders advised relative to its suitability for cotton-dusting purposes. In addition, about 1,500 samples of calcium arsenate collected by the official inspectors of the Federal Insecticide and Fungicide Board were tested for plant injury and weevil toxicity. The information secured from these tests, of course, served as a basis for the decisions of the board with regard to whether such material should be sold.

In connection with the chemical work, the manufacturers have been interested in the problem of standardizing calcium arsenate, and considerable progress has been made with regard to improving the material on the market for cotton dusting. In the past there has been no definite means of measuring the physical quality of calcium arsenate, and this has resulted in much unsatisfactory material being distributed. There has now been designed a standard tester which makes the operation purely mechanical and this has been adopted by the various manufacturers.

At the end of the season of 1920 a survey was made of the results secured by farmers in various portions of the cotton belt, and an attempt made to analyze the reasons for success or failure in poisoning. A number of important points developed in this study, and it was soon found that the rapid use of calcium arsenate had taken the work into territory where the field force was not prepared to issue advice, and an undesirable number of failures were resulting. Consequently the work was completely reorganized in 1921, and 11 new stations opened in sections ranging from South Carolina to south Texas with a view to studying the local conditions for cotton dusting, as well as attempting to advise the farmers in each section as to the best methods to pursue.

TOBACCO INSECTS.—The tobacco hornworm still is the most important tobacco pest in Kentucky and Tennessee. Diversification of crops, the high price of labor, and the passing of the careful and efficient hand wormer keep the machinery and dosage problems in the forefront. During the past summer a somewhat rough working model of a mule duster, especially adapted for use in the tobacco field, was constructed at the Clarksville, Tenn., laboratory and tested on 75 acres of tobacco. This machine applies the dust insecticide to two rows of tobacco at the same time, does the work very thoroughly, and is handled as easily as the ordinary plow. Using this machine, one man and a mule will do more and better work than two men with hand dusters. A demand for it has already been created; consequently every effort will be made toward perfecting the machine during the year.

Plant beds for the setting of about 800 acres of tobacco were dusted with arsenate of lead during the spring just passed to reduce as far as possible the number of hornworms in the area selected for control of hornworms by reduction of the hibernating generation. This experiment will be prosecuted vigorously in the fall and it is ex-

pected that some indication of its probable value will be obtained in 1922.

A very excellent piece of work was done during the spring and early summer at Quincy, Fla., in carrying through two generations of the tobacco flea-beetle in the laboratory. The records checked exactly with the appearance of the first and second generations in the field. A third generation also was bred entire, though not in lineal line with the first two. Climatic conditions helped to control both the tobacco thrips and the tobacco flea-beetle in the Georgia-Florida tobacco belt, so that little advance could be made in perfecting remedies for either pest. However, the dusting and spraying as recommended by the agent in charge served, in conjunction with the peculiar weather conditions, to reduce damage by both insects to a minimum.

The tobacco splitworm, which threatened to wipe out the tobacco industry at Dade City, Fla., a few years ago, this year made its appearance in noticeable numbers first in the Quincy section. This outbreak is being watched and studied very carefully and will be given particular attention in the spring, so that the necessary repressive measures may be adopted in time should the infestation prove to be alarming.

SUGAR-CANE, RICE, AND CACTUS INSECTS.—During the summer of 1920 the work of collecting tachinid parasites of the sugar-cane moth borer in Cuba and forwarding them to Louisiana was continued, a large number of parasites being secured. The work was made possible largely by the contributions of Louisiana sugar planters, nearly \$7,000 having been raised to pay the salaries and expenses of four collectors in Cuba working under the direction of an employee of this bureau. A sufficient number of parasites was obtained to allow of a colony being placed on the plantation of every contributor to the fund.

The parasites were afterwards found to have attacked the larvæ of the moth borer at the Louisiana Sugar Experiment Station, New Orleans, on various Louisiana plantations, and on a plantation near Brownsville, Tex., where some were released. There is some evidence that the parasite passed the winter of 1920-21 successfully, and it is believed that it will be found to be an efficient factor in control.

Good results continue to be obtained with the system which the bureau, in cooperation with the Louisiana Sugar Experiment Station, devised of avoiding the destruction of the native egg parasite of the moth borer by avoiding the burning of cane leaves left on the fields after the cutting of the cane. Instead of being burned, the leaves are partially plowed under, thus causing them to decay and combine with the soil. Not only is the moth borer controlled in some degree, but the soil is left in much better condition than before plowing. The Cuban parasite will assist in the control afforded by the egg parasite.

INSECTS AFFECTING THE HEALTH OF MAN AND DOMESTIC ANIMALS.

CONTROL OF FLIES AND OTHER INSECTS IN ESTABLISHMENTS OPERATING UNDER FEDERAL MEAT INSPECTION.—This project, which is carried out cooperatively with the Meat Inspection Service of the Bureau of

Animal Industry, was given some attention during the year. A Survey was made of the packing houses in the principal centers in the Central States to further study the practical problems involved in fly control under packing-house conditions. It was gratifying to note the very marked improvement which had taken place in regard to fly conditions about these establishments as compared with conditions when the work was begun in 1915. While it will be found necessary to wage a continual fight against flies around packing establishments, many of the problems have been solved by the permanent elimination of the breeding places on the premises through modification in construction, equipment, and methods.

SCREW WORMS.—Much attention has been given to the study of the screw worm, and especial stress has been laid on the control of this destructive live-stock pest under range conditions. In this work close cooperation has been maintained with the experiment station of the Texas Agricultural College, one investigator being located at substation No. 14 of the Texas Experiment Station in the center of the sheep and goat raising region near Sonora, Tex. In the vicinity of that station extensive tests have been carried out with the control of the screw-worm fly by systematic destruction of carcasses and trapping and poisoning of adults. Much attention has been given to the question of developing a suitable material for destroying the maggots and repelling the flies from wounds. As a result of this work some promising formulæ have been developed and are being given to the stockmen in the form of a bulletin from the Texas Agricultural Experiment Station.

The Bureau of Chemistry also has cooperated with this bureau in initiating an extensive series of experiments to determine the value of various chemical compounds and mixtures of them as repellents for the screw worm and other flies, as attractants for the flies, and as larvicides. No very definite conclusions have been reached in connection with this work, but it is hoped that certain fundamental principles underlying the chemotropic reaction of flies will be determined.

As a result of our campaign against the screw worm in southwest Texas, numerous stockmen have purchased flytraps of the type advocated and are operating them on their ranches. On this account it seems advisable to get further information on the attractiveness of dried slime and other concentrated dried baits. Some very promising results are being secured along this line and some stockmen report a very material reduction in screw-worm cases since the fly-trapping campaign was begun.

OX WARBLER.—Investigational work dealing especially with the seasonal history of the destructive cattle pest known as warbles or "wolves" has been continued. Large-scale experiments to test the toxicity of various chemicals to the warbles have been carried out and a very effective ointment has been hit upon. This consists of a mixture of iodine and vaseline. It has been found that 100 per cent efficiency can be secured against the common species, *Hypoderma lineatum*, by pressing this material into the warble holes in the backs of cattle. While other chemicals have been found to give nearly as high killing power, this mixture has the advantage of simplicity of application and a considerable percentage of the grubs drop out of the backs of the cattle after they have been killed.

POULTRY PARASITES.—A test to determine the effect of lice on fowls, especially as determined by egg production, has been continued throughout the year, and some attention has been given to the control of other destructive parasites such as the feather mite, roost mite, chicken tick, and sticktight flea. This work has been more or less along the line of securing the adoption of satisfactory control measures already worked out and published upon.

INSECTS AFFECTING THE HEALTH OF MAN.—The work of the bureau laboratory at Mound, La., on malaria mosquitoes has been continued. These investigations relate to the American species of *Anopheles* that transmit malaria, the conditions that favor the production of these mosquitoes, the regions where these conditions exist, the requirements for malaria transmission, the development of the malaria parasite in the body of the mosquito, the resulting human infection, and the effect of such infection upon the time and efficiency of those having the disease. Malaria, by reason of the breeding habits of *Anopheles*, is a rural disease. It affects the farming class more than any other class of people with the possible exception of the people engaged in the lumbering industry in the swampy regions. The economic loss runs into hundreds of millions of dollars annually aside from the nondevelopment of great tracts of fertile land where malaria is known to exist. The work is in contact with other agencies interested in the control of malaria in this country, including the International Health Board, the Prudential Insurance Co., Tulane University of New Orleans, the National Malaria Committee, and the United States Public Health Service.

The lines of work have developed from that of a rather general survey to that of intensive investigation. The general line and policy of the work—that is, the relation of malaria to crop production and to agricultural development, the mosquitoes concerned in the transmission of the disease, the sources of these mosquitoes, and the methods of control of these mosquitoes under typical plantation and farming conditions have not been changed, but the lines have been extended and reduced to certain definite projects. The control of malaria rests on the control of the mosquitoes that convey the disease. The methods of control must rest upon the biology of these mosquitoes and the problem, therefore, primarily is an entomological one. The disease being rural, it is likewise an agricultural problem. The work then becomes the foundation of the future progress in the control of this great menace to large areas of fertile land.

TROPICAL AND SUBTROPICAL FRUIT INSECT INVESTIGATIONS.

The immediate direction of the work of this branch was taken over by Dr. A. L. Quaintance in December, 1920, certain features of the work being handled in cooperation with the Federal Horticultural Board.

INSECTS AFFECTING CITRUS FRUITS IN CALIFORNIA.—The citrus red spider is at present one of the most important problems in southern California. During the year experiments were carried on with the comparative efficiency of several sprays, including lime-sulphur and distillate cresylic-acid soap emulsion. The latter was found

to be superior to the lime-sulphur spray. Its efficiency has been demonstrated in several citrus districts and it has been adopted by a large number of growers with great success in the control of the red spider. Careful biological studies of the red spider and mites on citrus trees are being carried on in the interior southern California districts. Further studies have been made with liquid hydrocyanic-acid gas in order to gain more satisfactory results, especially with the larger trees. The fumigation schedule formerly in use has been revised, and the revision has been generally adopted with notably better results.

In order to get definite data on what has come to be known as the "resistant black-scale infestation" in two definite areas of the southern California citrus district, fumigation operations were carefully checked during the season of 1920. The resistance of the scale was proven, and the necessity for improved dosage and improved methods was demonstrated.

Field demonstrations in mealybug and Argentine ant control were conducted throughout the infested citrus districts and have resulted in campaigns of eradication over a very large acreage. The success of the methods has reduced the mealybug menace to commercial control throughout the entire area. Manuscript on this subject has been submitted and is in the course of publication, as well as a paper on the control of the citrophilus mealybug. In cooperation with the Federal Horticultural Board a biologic study of the red date palm scale has been undertaken and experiments conducted in vacuum fumigation for the destruction of the scale on palm offshoots. Preliminary experiments indicate the possibility of controlling this insect by this method. Manuscript on the red date palm scale has been submitted and is now in the course of publication.

INSECTS AFFECTING CITRUS FRUITS IN FLORIDA.—The development of a combined oil-emulsion and Bordeaux spray to control insect pests and fungous diseases of orange and lemon groves has been studied. There exist in the Florida groves certain fungi which kill the white fly and various scale insects, and the studies of the above-mentioned combination spray have been complicated by this fact.

Work on the rust mite has been continued and marked progress has been made. Several forms of sulphur are being tested to learn their relative values. Experiments are under way with several new insecticides which seem likely to be useful in the control of various citrus insects.

The camphor thrips project, which had been carried on cooperatively with the Florida station, was taken over by the bureau laboratory. The biology of the insect has been worked out, and it has been found that the injury of the insect may be obviated by cutting the camphor trees back to the ground instead of pruning them back to stubs 4 or 6 feet in height. This pruning operation destroys the insects and has the advantage of permitting the trees to sprout at the crown roots.

The special investigation of the fungous diseases of insects attacking citrus fruits in Florida was begun during the summer of 1920. Two different species of fungi have been discovered associated with and apparently preying upon the rust mite, and studies are under way to determine whether these are parasitic, and if so how they can

be utilized in the control of the pest. A fungous disease of the citrus mealybug, first detected in 1917 in Louisiana, has been found to be largely responsible for the control of this pest in Florida. It kills young mealybugs before they can reproduce, and in fact one stage of the fungus occurs only in the young crawling individuals. A number of fungous diseases attack the white flies and scale insects of Florida, and these are also being studied in the hope that they may be used practically. One apparently new fact has been discovered in connection with the infection of white flies and of the purple scale by their fungous diseases, namely, that the infection takes place through the underside of the insects after they have become stationary, and does not regularly take place through the back. With this knowledge an increased efficiency of the disease should be gained by applying a spore-bearing spray at a time to insure maximum infection of the insects.

STUDIES OF GREENHOUSE INSECTS.—The strawberry rootworm continues to be a pest of much importance to roses under glass in certain regions of Pennsylvania, and in cooperation with the Bureau of Plant Industry of the Pennsylvania Department of Agriculture further important advances have been made in our knowledge of the biology of the insect, and especially of control methods. It has been ascertained that the adults are best destroyed by fumigation of the infested greenhouses with hydrocyanic-acid gas at the rate of $1\frac{1}{2}$ to 2 ounces of sodium cyanid per 1,000 cubic feet, with an exposure of two hours. Owing to the severe burning which accompanies this treatment, the hydrocyanic-acid gas should be used only during the "drying off" or resting periods. The method is suitable only for the single unit type of house. Dusting rows with sulphur and arsenate of lead (9 to 1) also showed promise as a repellent for the adults when applied after the rose bushes have been cut back and started for the ensuing season. For the treatment of the larval and pupal stages in the soil, wood ashes and tobacco dust applied alternately at 5-day intervals have given some benefit. This treatment should be applied soon after the egg-laying period has commenced, which is about the middle of March.

In addition to the principal work on the strawberry rootworm, studies have been made of the greenhouse leaf-tier. Experiments indicate considerable control by fumigating, dusting, dipping, and spraying. Dusting with sulphur and arsenate of lead has thus far given most encouraging results.

Additional data have been obtained on the general subject of fumigating greenhouses and the effect of same in the control of various greenhouse insects and on the plants treated. In the case of *Chrysomphalus biformis* on orchids the use of sodium cyanid at the rate of 1 ounce per 1,000 cubic feet of space with an exposure for one hour gave a mortality of from 98 to 100 per cent, with no injury to the plants. Similarly 98 per cent control of the greenhouse *Orthezia* was obtained and also with the black oleander scale, *Saissetia oleae*. It has been found practical to destroy the onion thrips on carnations by a fumigation with one-half ounce sodium cyanid per 1,000 cubic feet of space for a period of one hour. In addition to the control work above reported, necessary attention is being given to working out biologies and life histories of various greenhouse pests as a basis

for reducing their injuries. Much progress is being made in this general subject and its importance to the florist industry of the country warrants its enlargement.

INSECTS AFFECTING MANGO, GUAVA, AVOCADO, AND OTHER SUBTROPICAL FRUITS.—This investigation is being carried out, with headquarters at Miami, Fla., where unusual opportunities are present for its prosecution. Material progress has been made in the accumulation of knowledge concerning the various insect pests of the avocado, mango, papaya, etc., and manuscripts for Farmers' Bulletins have been submitted on the principal insect pests of the mango and of the avocado. A technical paper has been submitted for publication on the avocado red spider, *Tetranychus yothersi*. During the year a technical study of the avocado white fly has been continued, and many tests made with oil emulsions to determine what strengths are most efficient and economical. Other insect enemies of subtropical plants are being studied, as the avocado leaf-roller, the avocado leafhopper, the papaya fruit fly, etc. In addition to the biologic work under way, much time has been given to the development of sprays and other methods of control suitable for use on subtropical plants. Much of the water used in this territory is either brackish or contains bicarbonate salts, and oil emulsions are made with difficulty.

INVESTIGATION OF THE MEDITERRANEAN FRUIT FLY AND MELON FLY.—The work of this laboratory at Honolulu has consisted primarily of inspection and certification of pineapples, bananas, and taro for shipment from Hawaii to the mainland in cooperation with the Federal Horticultural Board. The demand on the office for inspection and certification of shipments has materially increased. Thus, about 160,000 bunches of bananas were passed for shipment to California, while several hundred bunches were condemned as unsafe for shipment. Several thousand crates of pineapples, taro, and other vegetables have been examined and certified as free from injurious insects.

As in previous years, careful daily records have been obtained of the extent of infestation of the different host fruits by the Mediterranean fruit fly and the percentage of parasitism of this fly by four species of introduced parasites, requiring much tedious attention. A manuscript on "Work and Parasitism of the Mediterranean Fruit Fly during 1919-20" is in the course of publication. In cooperation with the Office of Stored Product Insect Investigations of the bureau, investigations are underway of three species of bruchids of much importance to algaroba, the ground seed pods of which constitute a valuable stock food, and which is increasing in use. While certain parasites have been discovered attacking these bruchids, it is evident that additional parasites should be introduced to effect the control of the weevils in the field. Consequently an agent of the bureau has given special attention to searching for parasites in the southwestern parts of the United States. Much biologic and other information has been accumulated concerning the weevils, which will be of value in handling any parasites which may be introduced.

INVESTIGATION OF FRUIT FLIES AND OTHER TROPICAL AND SUBTROPICAL FRUIT INSECTS IN THE CANAL ZONE, PANAMA.—Work has been continued at this field station along the lines followed in the past. Close survey is maintained of the injurious insects of the region, especially to detect those recently established, in view of the large amount of

cargoes which pass through the canal from various parts of the world. Data are being accumulated on the life history, destructiveness, and methods of control of various local and introduced insects, especially in view of the danger of their establishment in the United States.

INSECTS AFFECTING FOREST RESOURCES AND SHADE TREES.

The work of the branch of forest entomology has been continued under the supervision of Dr. A. D. Hopkins.

INSECTS AFFECTING FOREST TREES.—An especial effort has been made during the year to ascertain exact conditions throughout the western forests regarding the present situation relative to the damage done by the four most destructive insect enemies of North American forest trees, namely, the western pine beetle, the mountain pine beetle, the Black Hills beetle, and the southern pine beetle, and it is well to place these results on record here, although the discussion relates also to cumulative conditions during a period of years and to the rise and fall of what may be compared to epidemics.

The Pacific slope region.—The western pine beetle has continued to kill a considerable percentage of the largest and best yellow pine in the national forests, the national parks, the Indian reservations, and privately owned areas, especially in central to northern California and southern Oregon.

On the northern drainage of the San Juan River in California there is an area 20 miles long by 18 miles wide, including about 130,000 acres with a stand of about 2,000,000,000 board feet of timber, and in this area detailed studies have been made. The reports of the experts show that in the years 1913 to 1919, inclusive, there was an average loss in this area of about 4,800,000 board feet of pine timber annually, principally yellow pine, caused primarily by the western pine beetle. From 3,000,000 feet killed in 1913, the loss increased to 9,000,000 and then gradually declined to about 2,000,000 feet in 1919 and to less than 1,000,000 feet in 1920, which represents about an average minimum percentage of loss annually to the pine forests of the Pacific slope.

The results of investigations by the Bureau of Entomology and the Forest Service in Klamath County, Oreg., during the past year led to the conclusion that the damage done by the western pine beetle fluctuates from year to year between 0.1 and 0.3 of 1 per cent of the total value of the timber. It was estimated that on privately owned land only, this beetle kills from 7,000,000 to 24,000,000 board feet each year, and that within the portions of the three national forests and the Indian reservation contained in Klamath County 11,000,000 to 32,000,000 board feet are killed. This gives a total of from 18,000,000 to 56,000,000 feet and about 2,000,000 acres of yellow pine timberland in the county. In fact the amount of timber that will be killed by this beetle in Klamath County during 1921 will probably amount to over 56,000,000 board feet. It was also estimated that during the 10 years 1911 to 1920 the total timber loss was 3,000,000,000 having a stumpage value of over \$4,000,000.

These are two instances only; but throughout the pine timber area of the Pacific slope trees are dying each year as scattering in-

dividuals, with real epidemics here and there. Thus the loss is undoubtedly enormous. That it is a preventable waste is certain, since practical methods have been worked out and demonstrated by this bureau which, if put into effect, would prevent a large percentage of this loss.

In addition to the loss of yellow pine caused by the beetle in question, there is a proportionate loss of the best sugar pine caused each year by the mountain pine beetle. For example, out of a total volume of 247,470 board feet of infested yellow and sugar pine trees in the San Joaquin area actually counted and marked in 1919, 129,060 feet was killed sugar pine.

Northern Rocky Mountain region.—Reports from eastern Washington and Oregon and the whole of Idaho, Montana, and Wyoming show that the recent enormous losses of yellow pine from the western pine beetle, and of mountain or western white pine and lodgepole pine from the mountain pine beetle, have diminished to normal. There is, however, evidence of increased infestation in some sections of the forest, and now is the time for an organized cooperative effort to maintain the minimum loss and to act radically should an epidemic start.

Southern Rocky Mountain region.—Although the Black Hills beetle has in past years caused an enormous loss in Rocky Mountain yellow pine timber, there have been no late reports of extensive injury. This beetle, however, kills a large amount of timber in this region each year, and an extensive project, involving the Grand Canyon National Park and the adjoining national forests, is being inaugurated under the general advice of a representative of this bureau to take action toward reducing the prevailing losses from an endemic stage to a minimum normal.

Eastern States.—The condition is about normal. There have been a few sporadic outbreaks of the southern pine beetle in the pine timber of the Southern States, but this insect has not attracted much attention during the past year. There is, however, constant danger of an epidemic outbreak.

Partly through the dissemination of information on simple methods of control, the hickory barkbeetle, which severely damages hickory forest, shade, and nut trees in the East, has attracted very little attention during the past year.

CONTROL WORK AGAINST THE TREE-KILLING BEETLES.—There has been a greatly increased interest among Federal foresters and private owners in the practicability of control work. During the past year this work has been continued on one of the most extensive projects yet undertaken. This is known as the San Joaquin project, on which \$23,760 was spent up to the close of 1919. Since the epidemic character of the infestation was reduced to a minimum normal, attention has been directed to the maintenance of control by means of trap trees and the treatment of scattering infested trees in connection with the regular fire-patrol work.

The so-called Antelope control project is on private lands in northern California, and is being supervised by a representative of the bureau, who has charge of the field station at Ashland. The work during the past spring covered an area of 32 sections, and up to June 16 3,200 trees had been treated, an average of about 100 trees per section.

Largely through the initiative of the Klamath-Lake County Forest Fire Association of southern Oregon, an organization which previously expended more than \$25,000 in control work in the protection of yellow and sugar pine timber, the Legislature of Oregon passed a law at its last session requiring owners of timber to take necessary action toward the control of barkbeetles. The State legislature also forwarded a memorial to Congress which resulted in a special appropriation of \$15,000 to enable the bureau to cooperate with Federal and private owners and to furnish expert advice. A general conference was held at Klamath Falls, Oreg., on April 4 and 5, 1921, which resulted in the awakening of a widespread interest in the prevention of losses from insect damage to living timber on the Pacific slope and in the great encouragement of the forest entomologists of this bureau, who have deeply felt the apparent previous indifference of the lumber interests to the value of their work in establishing control methods. The efficacy of these methods has been demonstrated again and again, notably in northeastern Oregon and during the period of epidemics between 1900 and 1910 in the southern Rocky Mountain region; and that they have not been more generally adopted down to the present time is a grave misfortune.

INSECTS AFFECTING FOREST PRODUCTS.—Work on insects affecting forest products during the year has been limited to experimental tests with a large number of chemical sprays, submergence in water, seasonal cutting, etc., to prevent the serious damage by wood-boring insects to saw logs, lumber, and woods used in log houses and rustic work; the prevention of damage to wood in buildings, telegraph and telephone poles, etc., by white ants; and the prevention of damage to seasoned hardwood products by powder-post beetles.

The preventive spray which gave the greatest promise as a practical means of preventing the attack of destructive wood-boring insects in crude forest products is a mixture of creosote and kerosene.

Water submergence and sun-curing were found to be effective against nearly all wood-boring insects and are practical methods wherever sufficient water is available.

Sun-curing alone, by placing the logs on skids or platforms above the ground and turning them occasionally, proved quite effective and to a limited number of logs is practicable.

Seasonal cutting: It was found by cutting trees at different times in the year at the Eastern Field Station, East Falls Church, Va., that, in general, and for most kinds of trees and insects, those cut between the middle of July and the middle of August gave the best results in preventing damage by wood borers.

It now remains to test these methods on a commercial scale in cooperation with actual lumbering and wood manufacturing operations.

Termite or white ant damage to utilized wood products has, as in the past, received special attention. Eighty-nine cases of damage to buildings and their contents in the United States were reported during the year; 17 of them were within the District of Columbia, and 16 from Indiana. The other reports included cases in the States of Alabama, Arkansas, California, Florida, Illinois, Iowa, Kansas, Louisiana, Maryland, Missouri, New Jersey, North Carolina, Ohio, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. In addition 9 cases were reported from other countries. A few cases of

special interest were damage to woodwork and stored books in the Library of Congress, flooring and stored material in the basement of the New National Museum, post cards in the post office at Elizabeth, N. J., and woodwork and contents in a building of the Union Stock Yards at Wichita, Kans.

It was found that in all cases the damage by this class of insects was largely, if not entirely, due to improper construction which allowed the entrance of the insects. It has been found that, in order to prevent damage, all woodwork in the foundation and basement floors must be completely protected by chemical treatments or concrete of a fine texture closely packed next to all woodwork. Cracks or openings through coarse unpacked concrete, allowing passageways for the insects from the ground, are often the source of the trouble.

Powder-post beetle damage to seasoned, stored, or utilized hardwood products, such as ash and hickory handles, and wagon, automobile, and airplane stock containing sapwood, is a common source of serious loss and expense throughout this and other countries. Forty-four cases were reported from the United States, 22 of which were damage to woodwork of buildings and furniture and 22 to seasoned lumber, vehicle stock, implement handles, veneer, walnut gun, and airplane stock, and blocks of briar wood from which pipes are manufactured.

Investigations during past years have shown that damage by powder-post beetles can be prevented by methods of handling the material and simple treatments of the wood by linseed oil, kerosene, etc., full information on which has been widely disseminated through publications and correspondence.

Sound wormy chestnut is of special value as a core or base for veneer work, but there is a prejudice against its use by some manufacturers in this and other countries because of the mistaken notion that it contains insects which will continue the damage. This damage is caused in the standing trees and logs, so that there is absolutely no danger of continued damage after the wood is seasoned. Information to this effect is contributing to confidence which will ultimately result in an increased demand for the immense amount of available sound wormy chestnut wood from trees killed by the chestnut blight.

INSECTS AFFECTING SHADE TREES AND HARDY SHRUBS.—Very limited funds were available for this work, and for the Eastern States it has been confined almost entirely to giving information by correspondence in response to a greatly increased number of inquiries. Much attention, however, has been given to field work, remedial experimentation, and biological studies at the field station at Los Gatos, Calif. The insects especially studied have been a bark scale on the Monterey cypress, the scale insects affecting hedge plants, the California oak worm, the twig girdler of the live oak, and a flat-headed borer which seriously damages shade and fruit trees, shrubs, and ornamental vines. With all these insects practical control means have been found. The European elm scale, seldom very serious in the East, has recently been accidentally introduced into the far Western States and there has become a serious pest. Elm trees have been planted extensively and are weakened and sometimes killed by this insect. A simple remedial treatment has been found which consists in a thorough washing of the trees by means of a fire equipment or a

power spray with plain water *at the time when the leaf buds are opening.*

Much work should be done with many of the shade-tree insects of the East, but funds are lacking.

THE BIOCLIMATIC LAW.—Intensive research work has been continued by Dr. Hopkins on the bioclimatic law, which was mentioned in my last annual report. Notable progress has been made in demonstrating that this law is applicable to all continental and insular areas of the world, with special reference to the studies of broad fundamental problems of agriculture, including those relating to entomological research and practice. For example, one of the most important problems for the consideration of entomologists relates to the introduction of insect pests from one part of the world to another. It is largely a question of the relations between life and climate—as to the environment of the original home of a species, the climatic range and limits of its natural distribution and that of the plant or animal on which it lives in one country, the place of its introduction into another, and the range and limit of similar climate and food conditions which are favorable for its natural or artificial spread from the point of entry. Through a knowledge of the natural laws and principles involved and of the history of past introductions of pests into this country, it is possible to predict as to the dangerous pests to be guarded against in the future, the places and regions in which they may become established if introduced, and the extent to which they may or may not spread.

It is evidenced that, through the knowledge to be gained by the application of the law, predictions could be made that would serve as reliable guides to the action to be taken to prevent both undesirable introductions and the expenditure of large sums of money in useless efforts to prevent introductions or spread in sections of the country where the insect, plant, or disease could not survive.

It seems, looking at it in a broad way, that this law has a world-wide application to problems that have not been solved and evidently can not be solved by any other method short of expensive explorations and detailed studies of local conditions.

BEE-CULTURE INVESTIGATIONS.

The work of the office of Bee-Culture Investigations, under the supervision of Dr. E. F. Phillips, has been modified during the year to return to investigational work, which was interfered with so greatly during the period of the war. The educational work which was begun during the war proved so helpful that some of this work has been continued and will doubtless form part of the regular work of the office in the future. The laboratory and apiary are still located at Somerset, Md., near Washington.

DEMONSTRATIONS IN BEEKEEPING.—The funds available for this work were still further reduced this year to provide additional funds for research work. The office is cooperating with six States in extension work in beekeeping, in all cases at least half of the funds being provided by the respective States. The extension work has been along the lines mentioned in detail in former reports, and emphasis is placed on the improvement in the methods of those bee-

keepers who are making this their life work, rather than to encourage a large number of persons to take up the keeping of bees. Specialization in beekeeping became more than ever pronounced during the war, and with a return to more normal conditions it is believed that it is only the well-informed specialist who can successfully produce honey at the prices offered for the product.

The extension short courses mentioned in earlier reports have been reduced in number, due to the greater emphasis on research work on the part of the men in the Washington office, and but one was given during the year. Because of the insistent demand for help of this kind it will be necessary for a number of years to hold such short courses, and several have already been requested for the coming season. The average attendance of all the short courses held by this office is well over 100 commercial beekeepers, who come to spend a full week studying the specialized problems of the beekeeper.

During the year an outline of a year's work for bee clubs was completed and is about ready for publication. It is believed that this will greatly stimulate interest in this branch of agriculture and will result in the development of better beekeeping methods than are in vogue in certain parts of the country.

The bulletin on swarm control (Farmers' Bulletin 1198), mentioned in the last report, has been completed. Three manuscripts for Farmers' Bulletins have been submitted for publication during the year, which differ from any of the previous publications of this office. It has been the experience of the office that in bulletins in which general principles underlying beekeeping practices are presented many beekeepers fail to choose the method best suited to their local conditions, and because of the plan of presentation many make no change in their methods. To overcome this difficulty the bulletins have been prepared giving specific directions for all phases of beekeeping for the white clover, buckwheat, and tulip-tree beekeeping regions. These regions cover the chief beekeeping territory of the part of the United States east of the Mississippi River. As soon as possible it is planned to prepare other bulletins for additional beekeeping regions of the country.

The correspondence of the office continues to be extensive. During the period of the war there was an enormous increase in the number of requests for information on all phases of beekeeping, and after the war there has been only a partial reduction to prewar conditions. It is a noticeable phase of the correspondence that more and more the requests for information are coming from specialists in beekeeping rather than from persons about to take up beekeeping.

Following the promulgation of the Postal Regulations of May 3, 1921, requiring that the candy used in mailing queen bees from uninspected apiaries be made from honey which has been boiled for 30 minutes in a closed vessel, queen breeders throughout the country have had considerable difficulty in making a satisfactory candy. This trouble has increased until during the summer of 1920 the losses ran into thousands of dollars. The problem of making a satisfactory candy for this purpose was taken up in cooperation with the carbohydrate laboratory of the Bureau of Chemistry, and Mr. Jay M. Smith was given a temporary appointment for this work. It was found that the trouble arises from the fact that the mixing of the

honey and powdered sugar is done at too high a temperature, and an article has been prepared for publication in one of the bee journals giving the results of this work, including detailed directions for making a satisfactory candy for mailing queens.

From time to time reports have appeared in beekeeping publications to the effect that honeys produced from certain nectars are poisonous to human beings, but up to the present it has been impossible to get data on which one could say positively that this is true. During the spring of 1921 several such reports came to the office and samples of honeys were obtained. Mr. Jay M. Smith took up a study of these honeys with a view to the isolation of the poisonous principle if present. This work is not yet completed, but there is reason to believe that there is such material present because of the physiological effects which these honeys have had on persons who have eaten them. If this work shows the presence of poison, it will then be necessary to devise a method of beekeeping for the region in which this is found, which will result in all of this honey being consumed by the bees in brood rearing, the hives being emptied before any other honeys are gathered.

WINTERING OF BEES.—As was explained in the last annual report, the work on the behavior and care of bees in winter was followed by a careful survey of the condition of the colonies in early spring and later throughout the early summer to see how their development was influenced by the various methods of wintering. During the spring and summer of 1920 careful measurements of the colony population and the amount of brood were taken on five colonies at intervals of a week. As no work of this kind had been done previously, one of the first things to be determined was a method for measuring the brood, and the results for the first season were not entirely satisfactory because the colonies were all weakened by the manipulation. Beginning with the first brood-rearing in the spring of 1921, this work was taken up again with different methods and is still under way. This is being done on 16 colonies at intervals of a week and the colonies have not been modified in their development by the methods now in use. Careful records are also being kept of the changes in the honey flow and of the various climatic conditions, so that it may be determined to what extent these factors influence the development of the colony. This work was begun in 1920 by Mr. Lloyd R. Watson and is being continued by Mr. Willis J. Nolan. Since this problem has many applications aside from the checking up of the wintering results, the project under which it is being done has been changed and it will be continued under the project "Behavior of bees."

DISEASES OF BEES.—During the year announcement was made of the discovery of the cause of the disease of adult bees known in Great Britain as the Isle of Wight disease. Since it was not known whether this disease exists in the United States it was thought best to make an immediate survey to determine this point, and work was begun on this June 1, 1921, by Mr. J. B. Moorman. Beekeepers throughout the United States were requested to send to the bureau samples of adult bees which seemed to be suffering from any disease whatever, and as a result of this request a large number of samples have been received. So far no bees have been received in which the mite causing the disease in question, *Tarsonemus woodi*, has been

found. In connection with this work the anatomy of the thorax of the worker bee is being more carefully studied than has before been possible. The receipt of such a large number of samples of adult bees has greatly increased our knowledge of the distribution of Nosema disease, concerning which but little has been determined. During the year 1,100 samples of diseased and suspected material have been received from beekeepers and apiary inspectors, the largest number in the history of the office. This increase is doubtless due to the campaigns carried on by the several States for the eradication of these diseases, and is not interpreted as showing any increases in the diseases of bees.

The work on the distribution of European foulbrood from the records of 15 years' work in the office, mentioned in the last report, has been continued and will soon be completed for publication. Because of the finding that this disease can not continue to do damage in localities where there is a regular and heavy honey flow early in summer, it has seemed desirable to make a preliminary survey of the country to determine in what places this disease is doing damage, and this has entailed a general survey of the beekeeping regions throughout the country. This material will be presented for publication soon, in so far as it has to do with the control of this disease, but because of the far-reaching importance of such a survey it is planned to continue the work under a new project, "Beekeeping regions of the United States," rather than to do all the work of this character under the "Disease" project.

It was found in the wintering investigations that during the winter months bees literally wear themselves out in heat production, and that the death of bees during this time must be attributed to this work. In order that the effects of this work be known, work was begun in June, 1921, on the problem of aging adult bees; the work being done by Mr. A. D. Shaftesbury. Beekeepers have long known that the aging of bees is determined by the work which they do rather than by days or weeks, and the purpose of this investigation is to learn what organs are affected by this work. It is impossible even to predict whether such knowledge will enable us to decrease the damage to the several organs affected. With the beginning of the fiscal year 1921-22 this work was transferred to the project "Physiology of bees."

PRESENT STATUS OF BEEKEEPING.—Honey production, like most other branches of agriculture, has suffered from the depressed condition of the markets, and the beekeeping industry is now passing through a serious crisis. Those beekeepers who produce the honey crop of the country are chiefly specialists, which means that they are one-crop farmers, and like other specialists in agriculture they have suffered more from the decline in prices than have those who diversify their production. In spite of this situation it is still believed that specialization is the only proper way to conduct the beekeeping of the country, in so far as the production of the marketed crop is concerned, and the commercial beekeepers of the country are giving serious attention to the problems which have arisen from the price decline. The estimates of honey production and the semimonthly honey market news service, issued by the Bureau of Markets and Crop Estimates, are of inestimable value in a time such as this.

INSECT PEST SURVEY.

The Bureau of Entomology, at the suggestion of the State agricultural experiment station and university entomologists, has instituted the Office of Insect Pest Survey, in order that both the bureau and these outside workers might be kept more closely in touch with entomological conditions throughout the country. The work was started in March under the supervision of Mr. J. A. Hyslop.

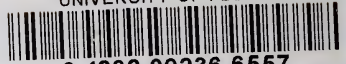
The object of the survey is to collect scientific data on insect conditions throughout the country, to study this data from month to month and year to year with relation to the several factors that cause insect outbreaks, and to prepare this information in the form of publications for the immediate use of all entomological workers throughout the country.

The survey obtains its information from 59 collaborators located in the several States; these are largely entomologists of the agricultural experiment stations, State entomologists, and entomologists in the State universities and agricultural colleges. Each collaborator assumes responsibility for collecting information on all insect outbreaks within his respective territory and transmitting this information to the central office in Washington, where it is digested, correlated, and edited for publication.

The survey issues a monthly bulletin of from 20 to 40 pages on the insect conditions of the preceding month. Reports of serious outbreaks are published as soon as received, in the form of special reports for the immediate information of working entomologists in near-by States, in order that they may be forewarned of possible outbreaks in their territory, and very urgent news is sent out in the form of a telegraphic emergency report. An annual summary of the year's insect conditions correlated with the weather conditions and other factors which influence insect abundance will be prepared, and in this summary an attempt will be made to give an estimate of the financial and material loss occasioned by insects.

Up to the present date the survey has issued 4 numbers of the bulletin, 15 special reports, and 1 telegraphic emergency report. It has received over 2,500 reports of insect outbreaks from its collaborators. Of these reports 1,005 were on fruit insects, 590 on truck-crop insects, 465 on cereal and forage crop insects, 249 on forest and shade-tree insects, 73 on greenhouse and ornamental plant insects, 53 on southern field-crop insects, 45 on insects affecting man and domestic animals, and 8 on insects infesting stored products.

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